Remarks:

Reconsideration of the application is requested.

Claims 1-12 are now in the application. Claim 1 has been amended. Claim 12 has been added.

The Examiner has stated that the charge density "ρ" has been used for two different meanings. On the one hand, it refers to the charge density in a thin layer or surface spreading in a direction vertical to the connecting line between the two active electrodes or orthogonal to the z-direction; on the other hand, it refers to the volume charge density normally used in Poisson's equation (or corresponding Maxwell equation). See page 3, lines 12-17 of the above-identified Office action.

Claim 1 has been amended to introduce "ρ_F" as the surface charge density, which is defined as a surface integral of the volume charge density in the z-direction.

The Examiner has also stated that a breakdown and also the breakdown location are only determined by the electrical field strength at the respective location in the semiconductor body, not by the integral as an averaged value. In other words, according to the Examiner's opinion, the local breakdown event cannot be determined by the integral of the charge density because the breakdown only depends on the local field strength not the global field strength. See from the last line on page 2 to page 3, line 9 and page 4, lines 6-7 of the Office action.

However, the Examiner's view overlooked the fact that a space charge zone is created by applying a blocking voltage between the drain and source in the semiconductor body, which extends over the entire distance W (compare Fig. 1). There are no more free charge carriers in this space charge zone so that the course of the electrical field is determined by the substantially evenly distributed fixed space charge zones. This means that there is practically a linear course of the field strength between the drain and the source. A breakdown occurs when the electrical field strength exceeds the critical boundary, namely when the critical charge quantity occurs.

The language of claim 1 has been amended to overcome any alleged deficiencies under 35 USC § 112, first and second paragraphs. The specification has been amended accordingly.

It is accordingly believed that the specification and the claims meet the requirements of 35 U.S.C. § 112, first and second paragraphs. Should the Examiner find any further objectionable items, counsel would appreciate a telephone call during which the matter may be resolved. The above-noted changes to the claims are provided solely for cosmetic and/or clarificatory reasons. The changes are neither provided for overcoming the prior art nor do they narrow the scope of the claims for any reason related to the statutory requirements for a patent.

In the section entitled "Claim Rejections - 35 USC § 103" on pages 5-14 of the above-mentioned Office action, claim 1 has been rejected as being unpatentable over Laska et al. ("A 2000 V-Non-Punch-Through-IGBT with Dynamical Properties like a 1000 V-IGBT", Int. Electron Dev. Mtg., New York, 1990 IEEE, pp.807-810) under 35 U.S.C. § 103(a); claim 3 has been rejected as being unpatentable over Laska et al. in view of Hutchings et al. (US Pat. No. 5,387,528) under 35 U.S.C. § 103(a); claims 1 and 3-5 have been rejected as being unpatentable over Park (US Pat. No. 5,702,961) in view of Laska et al. under 35 U.S.C. § 103(a); claim 6 has been rejected as being unpatentable over Park and Laska et al. and further in view of Fruth et al. (US Pat. No. 6,011,280) under 35 U.S.C. § 103(a); claim 7 has been rejected as being unpatentable over Park, Laska et al. and Fruth et al. and further in view of Feiler (US Pat. No. 6,236,068 B1) under 35 U.S.C. § 103(a); claims 8-10 have been rejected as being unpatentable over Park and Laska et al. and further in view of Yamaguchi et al. (US Pat. No. 5,821,586) under 35 U.S.C. § 103(a); claim 11 has been rejected as being unpatentable over Park and Laska et al. and further in view of

Yamamoto (Japanese Patent Application Publication No. JP 04-234173 A) or over Laska et al. in view of Yamamoto under 35 U.S.C. § 103(a).

As will be explained below, it is believed that the claims were patentable over the cited art in their original form and the claims have, therefore, not been amended to overcome the references. However, the language of claim 1 has been amended, as discussed above, to even more clearly define the invention of the instant application.

Before discussing the prior art in detail, it is believed that a brief review of the invention as claimed, would be helpful.

Claim 1 calls for, inter alia:

> a specific sheet charge density $\rho_F(z)$ of a thin layer having a surface perpendicular to a direction z between said pn junction and said second main surface such that: $\int_0^W \rho_F(z)dz \leq 0.9Q_c$, $\rho_F = \int \rho dF$

Laska et al. do not disclose the adjustment of the specific charge density in the semiconductor to values below 90% of the critical breakdown charge, as expressed by the equation $\int_0^W \rho_F(z)dz \leq 0.9Q_c$ as recited in claim 1 of the instant application.

However, the Examiner has stated that where the general condition is disclosed in the prior art, discovering the optimum or working ranges involves only routine skill in the art. The Examiner has alleged that the general condition is met because it is obvious that breakdown needs to be avoided in any vertical power semiconductor component.

Applicants respectfully disagree. The avoidance of undesirable breakdown in a vertical power semiconductor component is only a general goal, not a general condition for the invention of the instant application. The fact that such a general goal is known does not mean that all the measures to achieve the goal are also known. There could be infinite different measures to achieve the same goal. It is not fair to say that all these different measures involve only routine skill in the art.

Claim 1 is, therefore, believed to be patentable over the art and since all of the dependent claims are ultimately dependent on claim 1, they are believed to be patentable as well.

New claim 12 has been added, which incorporates the features of claim 1 and original claim 8.

The Examiner has rejected claim 8 over Park and Laska et al. and further in view of Yamaguchi et al., or alternatively over

Laska et al. in view of Yamaguchi et al. The Examiner has stated that neither Park nor Laska et al. necessarily teach the limitation of claim 8 (see lines 5-6 of item 5 on page 13 of the Office action).

Yamaguchi et al. only show a p^--conductive region 5 under an n^+-conductive region 4 in an n^--conductive semiconductor body 1 (see Fig. 4). These regions 4, 5 and 1 replicate two serial diodes connected back-to-back. Charge compensation is neither mentioned nor intended in Yamaguchi et al. Also, the region 5 completely wraps the region 4 so that no compensation can occur.

It is accordingly believed to be clear that none of the references, whether taken alone or in any combination, either show or suggest the features of claim 12. Claim 12 is, therefore, believed to be patentable over the art.

In view of the foregoing, reconsideration and allowance of claims 1-12 are solicited.

In the event the Examiner should still find any of the claims to be unpatentable, counsel would appreciate a telephone call so that, if possible, patentable language can be worked out.

If an extension of time for this paper is required, petition for extension is herewith made. Please charge any fees which might be due with respect to Sections 1.16 and 1.17 to the Deposit Account of Lerner and Greenberg, P.A., No. 12-1099.

Respectfully submitted,

For Applicants

WERNER H. STEMER
REG. NO. 34,956

YHC:cgm

May 12, 2003

Lerner and Greenberg, P.A.
Post Office Box 2480
Hollywood, FL. 33022-2480
Tel: (954) 925-1100
Fax: (954) 925-1101

$\underline{\text{Marked-Up Version of the Amended Paragraphs in the Specification and Marked-Up Version of the Amended Claims:}}$

The paragraph starting on page 14, line 17 and ending on page 15, line 4 now reads:

In accordance with an added feature of the invention, the layer thickness of the semiconductor body has a specific $\underline{\text{sheet}}$ charge density [ρ] ρ_F in a direction z between the pn junction and the second main surface such that:

$$[\int_0^W \rho(z)dz \le 0.9Q_c\,]\ \underline{\int_0^W \rho_F(z)dz \le 0.9Q_c}\ \underline{,}\ \ \underline{\rho_F = \int \rho dF}$$

in which $\underline{\rho\text{ is the volume charge density,}}$ Q_c, the critical breakdown [surface] charge$\underline{,}$ denotes a critical value of the [breakdown surface] charge $\underline{\text{quantity}}$ Q at which the electrical breakdown is reached, said charge quantity Q being linked to said electric field strength E between said first electrode and said second electrode by the [above equation] $\underline{\text{equations}}$

$$[\int_0^W \rho(z)dz \le Q\,]\ \underline{\int_0^W \rho_F(z)dz = Q}\ \text{ and Poisson's equation } \nabla E = -4\pi\rho\,.$$

The paragraph starting on page 20, line 4 and ending on page 20, line 23 now reads:

The critical value E_c of the field strength is linked to a charge density ρ by Poisson's equation

$$\vec{\nabla}.\vec{E} = -4\pi\rho\,, \qquad (1)$$

so that a relationship with a critical breakdown surface charge Q_c can be derived:

$$[\int_0^{Wsc} \rho(z)dz \le Q_c] \quad \underline{\int_0^{Wsc} \rho_F(z)dz \le Q_c} \qquad (2)$$

W_{sc} denotes the width of the space charge region (i.e. the region with $|\vec{E}| \neq 0$) when the electric field reaches the critical field strength E_c. According to the invention, the layer thickness W should then be selected in such a way that the space charge zone reaches the second main surface 3 before the field strength takes on the critical value E_c. In this case, the integration in following equation (3) has to be carried out over the entire layer thickness W of the semiconductor body 1 between the pn-junction between the semiconductor body 1 and the body zone 4 and the second semiconductor surface 3. In other words, the integral in Equation (2) should, for example, reach at most the value 0.9 Q_c so that, in the vertically structured power semiconductor component according to the invention, the following equation is satisfied:

$$[\int_0^W \rho(z)dz \le 0.9Q_c]\ \underline{\int_0^W \rho_F(z)dz \le 0.9Q_c}\ \underline{,}\ \underline{\rho_F = \int \rho dF}\ . \qquad (3)$$

Claim 1(amended). A vertically structured power semiconductor component, comprising:

a semiconductor body of a first conductivity type and having a first main surface and a second main surface opposite said first main surface;

a body zone of a second conductivity type opposite of said first conductivity type introduced into said first main surface;

a zone of said first conductivity type disposed in said body zone;

a first electrode making contact with said zone and with said body zone;

a second electrode disposed on said second main surface;

an insulating layer disposed on said first main surface;

a gate electrode disposed above said body zone and separated from said body zone by said insulating layer; and an intersection of said semiconductor body and said body zone defining a pn junction;

said semiconductor body having:

a layer thickness between said pn junction and said second main surface selected such that, when one of a maximum allowed blocking voltage and a voltage just less than this[,] is applied between said first electrode and said second electrode, a space charge zone created in said semiconductor body meets said second main surface before a field strength E created by an applied blocking voltage reaches a critical value E_c at which an electrical breakdown is reached; and

a specific sheet charge density [ρ(z)] $\rho_F(z)$ of a thin layer having a surface perpendicular to [in] a direction z between said pn junction and said second main surface such that:

$$[\ \int_0^W \rho(z)dz \le 0.9Q_c\ ]\ \underline{\int_0^W \rho_F(z)dz \le 0.9Q_c}\,\underline{,}\ \ \underline{\rho_F = \int \rho dF}$$

in which ρ is the volume charge density, Q_c, the critical breakdown [surface] charge, denotes a critical value of the [breakdown surface] charge quantity Q at which the electrical breakdown is reached, said charge quantity Q being linked to said electric field strength E between said first electrode and said second electrode by the [above equation] equations

[$\int_0^W \rho(z)dz \leq Q$] $\underline{\int_0^W \rho_F(z)dz = Q}$ and Poisson's equation $\nabla E = -4\pi\rho$.